UNITED STATES GOVERNMENT

memorandum

DATE: May 2, 1989

REPLY TO ATTN OF: Field Supervisor, USFWS, Fish and Wildlife Enhancement, Raleigh Field Office, Raleigh, North Carolina

SUBJECT: Survey of Mercury and Other Metals in Fish and Sediments at East Lake Landfill and Alligator River National Wildlife Refuge

TO: Assistant Regional Director, USFWS, Fish and Wildlife Enhancement, Atlanta, Georgia (Attn: Regional Contaminants Coordinator)

Enclosed is the report on the 1986 survey for mercury and other metals in fish and sediments resulting from the discharge of effluent from the East Lake Landfill on and adjacent to Alligator River National Wildlife Refuge. If you have any questions, please contact Kate Benkert (919-856-4520 or FTS 672-4520).

for Mike Gantt

cc: Refuge Manager, Alligator River NWR, Manteo, NC
ARD, Refuges and Wildlife, Atlanta, GA
Parley Winger, USFWS, Athens, GA
Division of Environmental Contaminants, Washington, DC

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Survey of Mercury and Other Metals in Fish and Sediments at East Lake Landfill and Alligator River National Wildlife Refuge, Dare County, North Carolina.

Introduction

Since 1980, Dare County has operated the East Lake Landfill as a disposal site for municipal solid waste. The landfill is located in the northwestern portion of Dare County (Figure 1), north of U.S. Highway 64 and adjacent to Alligator River National Wildlife Refuge (NWR). The County received an NPDES permit in 1983 to discharge landfill drainage effluent into Deer Creek. Repeated violations of effluent limitations for mercury and biological oxygen demand (BOD) prompted the initiation of this study in 1986 to evaluate the potential impacts, if any, to Refuge resources.

Acknowledgements

The U.S. Fish and Wildlife Service gratefully acknowledges Pete Kornegy and Al Simpson, North Carolina Wildlife Resources Commission, Division of Inland Fisheries and Peggy Puett, Beth Judge and Glenda Lewis, volunteers with the North Carolina Marine Resources Center-Manteo, for their assistance in sampling fish.

Site Description

East Lake Landfill was constructed in a palustrine forested wetland. The landifll is approximately 60 acres in size, of which 30 acres are used for municipal waste disposal. A collector pond (Figure 2), located in the northeast quadrant of the site, receives drainage from the active landfill surface. The collector pond is permitted for a single effluent discharge point into an unnamed tributary which flows into Deer Creek.

During a site inspection on November 18, 1985, Service biologists located two discharge points from the collector pond. The first point was from a 6-inch diameter white PVC pipe discharged onto upland within the landfill, with flow directed through a culvert into a collector ditch. This collector ditch directed the discharge to the northeast corner of the landfill where it would flow either overland and northeast towards Deer Creek or into the canal forming the eastern boundary of the landfill. An inspection of the southern end of this canal at Highway 64 indicated that during high water, overflow into the canal paralleling Highway 64 occurs. This canal connects into Hooker Gut.

The second discharge point was located north of the collector ditch, outside of the landfill berm. This discharge originated from a 4-inch diameter black PVC pipe that ran from the collecter pond, through the culvert and was buried at the point at which it crossed the collector ditch. Effluent was discharged from the buried pipe approximately 100

feet north of the collector ditch. A large hole, approximately 3 feet long, two feet deep and 2 feet wide, had been gouged out by the force of the discharged water. The effluent from this discharge point did not enter the collector ditch, but flowed predominantly to the east with lesser volumes to the west, north and south.

A second pond, known as the eel pond, is located in the northwest quadrant of the landfill. This pond receives natural drainage only, which is discharged into a red maple/black gum forested wetland, immediately north of the berm (Figure 2).

Sediments were collected from five sites designated LF1 through LF5. Site LF1 was at the collector pond discharge point located outside of the landfill berm and Site LF2 at the eel pond discharge point (Figure 2). Site LF3 was located in Deer Creek (Figure 3) and Site LF4 at the Highway 64 canal (Figure 2). The control site, LF5 was located at Whipping Creek (Figure 1). Sites LF4 and LF5 were "blackwater" sites, which are typically highly colored and acidic. In addition, fish were collected from Sites LF3, LF4 and LF5 for metals residue analysis.

Methods

Sediments were collected during April, 1986 by either PVC cores (<2 inches depth) or scooping of surface sediments with a stainless steel spoon. Five sediment samples were collected at each site and deposited into a stainless steel container. The samples where thoroughly mixed and a subsample of the composite removed for metals analysis. One subsample was collected and analyzed for each site except the control site. Two replicate subsamples were analyzed from the control site. Samples were stored on ice until transported to either the Service's Raleigh Field Office or the Refuge for freezing. Sediment samples were not held on ice for more than 16 hours. All equipment was washed and rinsed with acetone, prior to each sampling.

Fish were collected from Sites LF3, LF4, and LF5 by gill net, seining and rotenoning during May, June and July, 1986. The fish were placed on ice immediately upon capture until transport to the Refuge for processing. The weight and length of each fish was recorded and the fish wrapped in acetone rinsed aluminum foil. Fish were frozen at the Refuge and transported at a later date to the Raleigh Field Office.

Sample collections were made by Kate Benkert and Judi Durda of the Raleigh Field Office. Pete Kornegy and Al Simpson of the North Carolina Wildlife Resources Commission, Division of Inland Fisheries provided their expertise, boat and other equipment for the rotenoning operations. Peggy Puett, Beth Judge and Glenda Lewis, volunteers with the North Carolina Marine Resources Center in Manteo, assisted with the July fish collections.

The samples were shipped for laboratory analysis on March 23, 1987. All samples were analyzed for metals at Environmental Trace Substances

Research Center, Columbia, Missouri. The analytical results were received by the Raleigh Field Office on July 24, 1987.

Results and Discussion

The presence of metals in sediments and soils is a function of various parameters which govern the mobility of the metal. These parameters include the pH, soil type, total organic carbon content, percent clay, pore size, soil oxygenation and permeability (Pohland and Harper 1986). Generally, as soil becomes more acidic (i.e. pH decreases), metal mobility increases.

The sediment data (Table 1) indicate elevated priority pollutant metal residues at the collector pond discharge site, LF1, relative to the other sites. These metals include arsenic, beryllium, chromium, copper, nickel and zinc. Other metals present in elevated concentrations include aluminum, barium, iron and vanadium (Table 2).

Transport of metals from Site LF1 into Deer Creek (LF3) and into the Highway 64 canal (LF4) is not indicated by the sediment data. The metals present in the effluent are either associated with particulate matter which rapidly settles out upon discharge at Site LF1 or are quickly sorbed onto available exchange sites in the soil/sediment matrix upon contact.

Although elevated relative to the other sites, the metal residues present at LF1 do not represent excessive metal contamination of the soil. The State of North Carolina has not established soil clean-up criteria for contaminated soils. Using the State of New Jersey criteria for priority pollutants in soils (Beyers 1989), all of the metal residues at LF1 are below the criteria levels for clean-up action. Using the State of Wisconsin interim criteria for disposal of sediments in water (Beyer 1989), only arsenic (14.0 parts per million) exceeds their criteria level (12.5 parts per million).

The mercury residues are elevated at all of the sites, including the control (Table 1). This reflects the general trend of elevated mercury concentrations found in the organic peat soils and in fish on the Albemarle-Pamlico Peninsula. This mercury enrichment of the soils is believed due to natural atmospheric deposition of mercury during peat formation.

The fish collections were not as complete as intended due to collecting difficulties in the habitats sampled and time restraints. Chain pickeral (*Esox niger*), largemouth bass (*Micropterus salmoides*), flier (*Centrachus macropterus*), bluegill (*Lepomis macrochirus*), pumpkinseed (*L. gibbosus*), yellow bullhead (*Ictalurus natalis*), channel catfish (*I. punctatus*) and bowfin (*Amia calva*) were collected and analyzed for metal residues. Only chain pickeral were captured at all three sites.

Significant differences in metal residues in the chain pickeral were not found to exist between the three sites (Table 3). The small number of samples and large standard deviations of some of the metals precludes meaningful statistical analysis. It should be noted though, that the smaller sized fish collected in the Highway 64 canal (LF4), carry a disproportionately greater concentration of mercury than the larger fish captured in Whipping Creek (LF5) and Deer Creek (LF3). This relationship continues to hold for the mercury residues present in some of the other fish species collected (Table 4).

Mercury is biomagnified as it travels up the food chain. Typically, predators such as chain pickeral, largemouth bass and bowfin will contain the greatest concentrations of mercury. Species, such as the bluegill, with omnivorous food habits will exhibit lower residue levels. The mercury residues present in the fish collected from all three sites (Tables 3 and 4) are elevated relative to mercury residues present in fish from other areas of North Carolina (North Carolina Division of Environmental Management 1982). This trend towards elevated mercury residues also is present in fish collected from the Albemarle-Pamlico Peninusla during the 1987-88 Hot Spot Study conducted by the Raleigh Field Office (FWS unpublished data).

The elevated mercury residues present in the fish and soils in the Albemarle-Pamlico region are most likely related to the presence of the organic peat soils and the associated acidic water quality resulting from the presence of fulvic, humic and tannic acids in the peat. The Albemarle-Pamlico Peninsula is dominated by organic soils. Relative to mineral soils, peat soils have a much greater cation exchange capacity which enables them to "capture" and retain relatively more divalent metal cations such as mercury, nickel, lead and copper. As pH declines, the cation exchange capacity decreases and the metals already present in the peat are increasingly mobilized and released (Gorham, Bayley and Schindler 1984). Thus, while the mercury residues in the fish are elevated overall, they are reflective of ambient conditions and mercury availability in this ecosystem.

As the smaller sized chain pickerals collected from the Highway 64 Canal (LF4) contained disproportionately greater mercury residues relative to their weight than the fish from Whipping Creek (LF5) (Table 3), mercury enrichment of the food chain may be occurring at a rate above ambient. It is not possible, though, to determine from these survey data whether the enrichment trend is definitive or if the landfill effluent is responsible for the enrichment.

Summary and Recommendation

Elevated metal residues were present in the sediments at the point of effluent discharge, Site LF1. Transport of metals from this site into the adjoining aquatic systems of Deer Creek and the Highway 64 Canal were not indicated by the sediment data. Mercury enrichment of the food chain in the Highway 64 Canal is suggested by the fisheries data.

The role of the landfill effluent in this possible enrichment remains undetermined.

Since the initial investigation of the problems at the Dare County Landfill in 1986, the facility received a Special Order by Consent to continue discharge of the effluent. The County has constructed an onsite wastewater treatment facility which presently is operational. Despite these improvements, the Dare County Landfill has had repeated noncompliance violations of their NPDES permit for biological oxygen demand (BOD) limitations and failure to submit monthly effluent testing reports. A bioassay inspection of the effluent on March 7, 1988 indicated toxicity, although the high BOD present may be implicated in the mortality of the test organisms. During an onsite inspection on September 22, 1988 the North Carolina Division of Environmental Management discovered illegal and deliberate discharging of clarifier sludge into Deer Creek through a pump and hose system. The direct disposal of the sludge into Deer Creek has in all probability resulted in the release of metals into the aquatic system. The County was ordered to cease the sludge discharge and clean up the sludge disposed into the creek. The NPDES permit for the landfill expires on August 31, 1991.

The Dare County Landfill is expected to reach its maximum capacity within the next few years. The County of Dare owns a 500 acre tract of land adjacent to the Refuge near Highway 264, which is under consideration for the future Dare County Landfill expansion. Given the operating record for the existing 60 acre landfill, it is not in the best interest of the Service to have this expanded facility located adjacent to the Refuge. The Service should maintain close communications with the County during the planning phases for the new landfill. In the event that the 500 acre tract is selected for the new landfill site, the Service should work closely with the N.C. Division of Environmental Management and the County of Dare to insure that: 1) effluent discharges are hydrologically isolated from the Refuge; 2) adequate effluent limitations and toxicity monitoring requirements are a part of the NPDES permit and are enforced properly; and 3) a trained and knowledgeable landfill operator is hired by the County and stationed onsite.

In anticipation of the possible selection of the 500 acre tract for the new landfill, the Service conducted baseline sampling of sediments and snapping turtles on and adjacent to the potential site in 1988. Samples were submitted for analysis of for metals, organochlorines and polycyclic aromatic hydrocarbons. Laboratory analyses have not been completed to date.

Due to the natural mercury enrichment of the aquatic food chain in this region of North Carolina, the installation of a wastewater treatment plant at East Lake Landfill and the approaching close of the facility, additional contaminant sampling by the Service at the site is not presently recommended.

Literature Cited

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Gorham, Eville, S.E. Bayley and D.W. Schindler 1984. Ecological effects of acid deposition upon peatlands: a neglected field in "acid-rain" research. Can. J. Aquat. Sci. 41: 1256 - 1268.

North Carolina Division of Environmental Management 1982. Basic monitoring program: data review 1980-81. N.C. Dept. Natural Resources and Community Development. 183 pp.

Pohland, F.G. and S.R. Harper 1986. Critical review and summary of leachate and gas production from landfills. EPA/600/2-86/073. 182 pp.

Table 1. Priority pollutant metal residues (microgram/gram dry weight or parts per million) in soils/sediments from the Dare County Landfill and adjacent areas. Mean +/- standard deviation provided for Control Site LF5 (n=2).

		SITE				
Metal ug/g		LF1	LF2	LF3	LF4	LF5
Arsenic	As	14.0	3.6	2.1	2.3	3.0 ± 1.1
Beryllium	Be	1.40	0.71	0.59	0.41	.65 ± .06
Cadmium	Cd	0.40	<0.2	0.4	<0.2	<0.2
Chromium	Cr	55.8	28.0	21.0	19.0	30.2 ± 0.2
Copper	Cu	17.0	3.9	9.2	3.3	6.8 ± 0.6
Lead	Pb	10.0	10.0	22.0	10.0	24.0 ± 0.0
Mercury	Hg	0.91	0.26	0.25	1.20	2.20 ± 2.55
Nickel	Ni	29.0	13.0	11.0	8.0	13.0 ± 1.4
Selenium	Se	0.33	0.39	0.89	0.31	0.78 ± 0.08
Zinc	Zn	154.0	47.9	43.0	37.0	36.7 ± 5.2

Table 2. Metal residues (microgram/gram dry weight) in soils/sediments from Dare County Landfill and adajacent areas. Mean ± standard deviation provided for Control Site LF5 (n=2).

		SITE				
Metal ug/g		LF1	LF2	LF3	LF4	LF5
Aluminum	Al	44100	25800	26400	19000	28500 ± 2263
Barium	Ba	132.0	88.4	71.7	47.0	70.6 ± 10.9
Boron	B	24.0	14.0	17.0	3.5	18.5 ± 0.7
Iron	Fe	48400	22000	11600	9240	15750 ± 2617
Magnesium	Mg	8080	2870	5390	2030	6430 ± 183.8
Manganese	Mn	337	645	55.8	52.5	91.9 ± 36.9
Strontium	Sr	61.4	69.5	92.8	17.3	84.8 ± 0.7
Venadium	V	75.6	39.0	30.0	24.0	38.5 ± 0.7

Table 3. Priority pollutant metal residues (microgram/gram dry weight = parts per million) in whole chain pickeral from Dare County, North Carolina. Value = mean ± standard deviation; (n) = number of composites.

		SITE		
Metal ug/g		LF3 (n=2)	LF4 (n=2)	LF5 (n=3)
Arsenic	As	0.58 ± 0.47	0.31 ± 0.06	0.65 ± 0.14
Beryllium	Be	<0.006	<0.006	<0.006
Cadmium	Cd	0.04 ± 0.2	0.05 ± 0.04	0.06 ± 0.03
Chromium	Cr	0.06 ± 0.5	0.03 ± 0.01	0.12 ± 0.13
Copper	Cu	1.40 ± 0.42	1.25 ± 0.07	1.50 ± 0.17
Lead	Pb	0.25 ± 0.07	<0.2	0.2 ± 0.1
Mercury	Hg	0.80 ± 0.65	1.60 ± 0.85	1.32 ± 0.32
Nickel	Ni	0.2 ± 0.1	0.2 ± 0.1	0.2 ± 0.1
Selenium	Se	1.14 ± 0.23	1.15 ± 0.21	1.02 ± 0.07
Zinc	Zn	155.0 ± 40.3	204.0 ± 46.7	139.7 ± 11.6
Composite mean weight (grams)		574 ± 230	368 ± 18	385 ± 98

Table 4. Mercury residue (micrograms/gram dry weight = parts per million) in fish collected in Dare County, North Carolina.

Species	Composite mean weight (gm)	LF3 (ug Hg/g)	LF4 (ug Hg/g)	LF5 (ug Hg/g)
Largemouth Bass	444	0.48		
Largemouth Bass	486		1.70	
Largemouth Bass	533		1.31	
Largemouth Bass	1100		1.37	
Flier	68			0.69
Flier	92		1.25	
Bluegill	26		0.45	
Bluegill	197	0.30		
Bluegill	244		0.77	
Bluegill	304		0.90	
Yellow bullhead**	95			0.57
Yellow bullhead**	595		0.95	
Pumpkinseed	89			0.36
Channel Catfish	2497	0.50		
Bowfin	1180	1.20		

**Yellow bullhead samples are individual specimens and not composite samples.

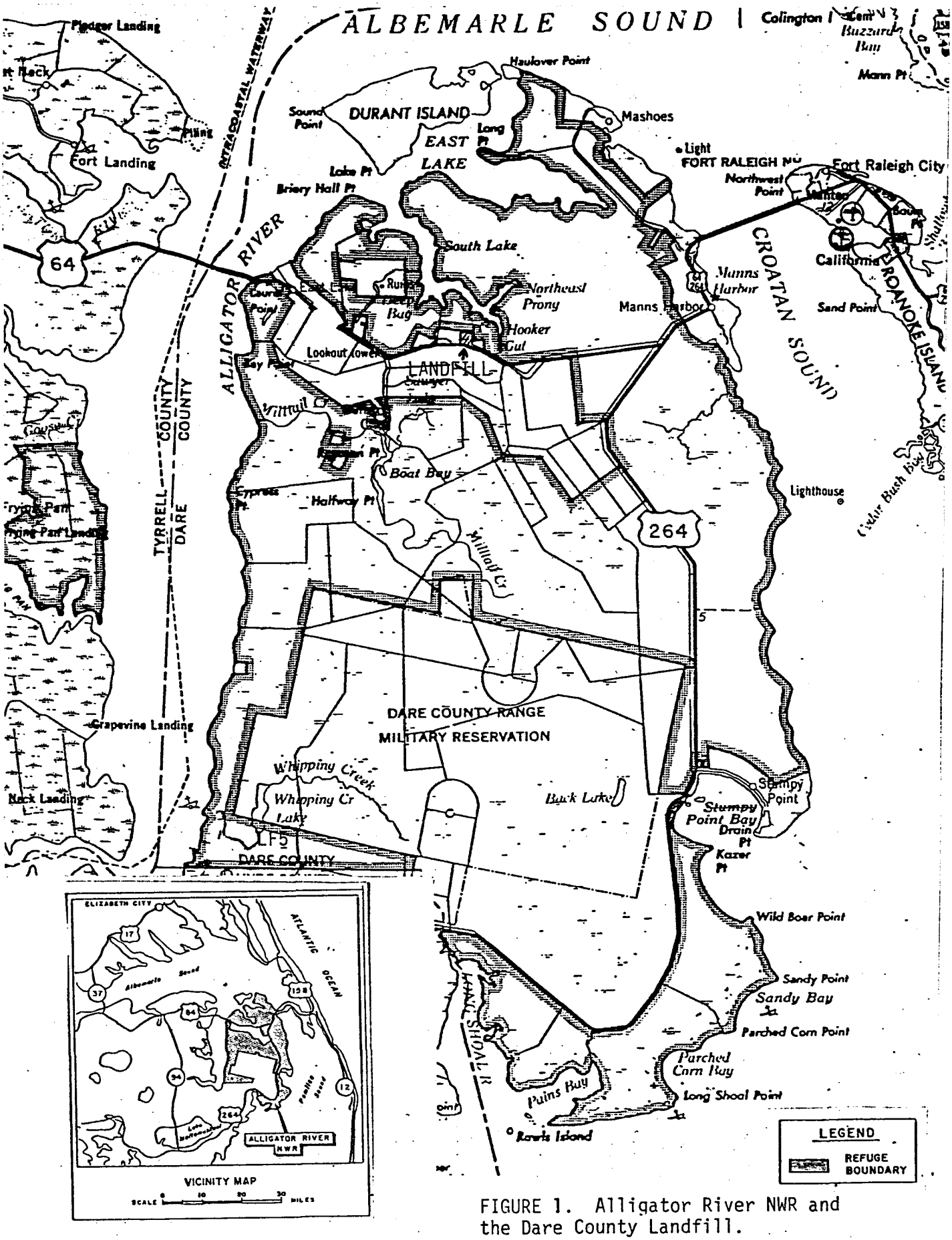

FIGURE 1. Alligator River NWR and the Dare County Landfill.

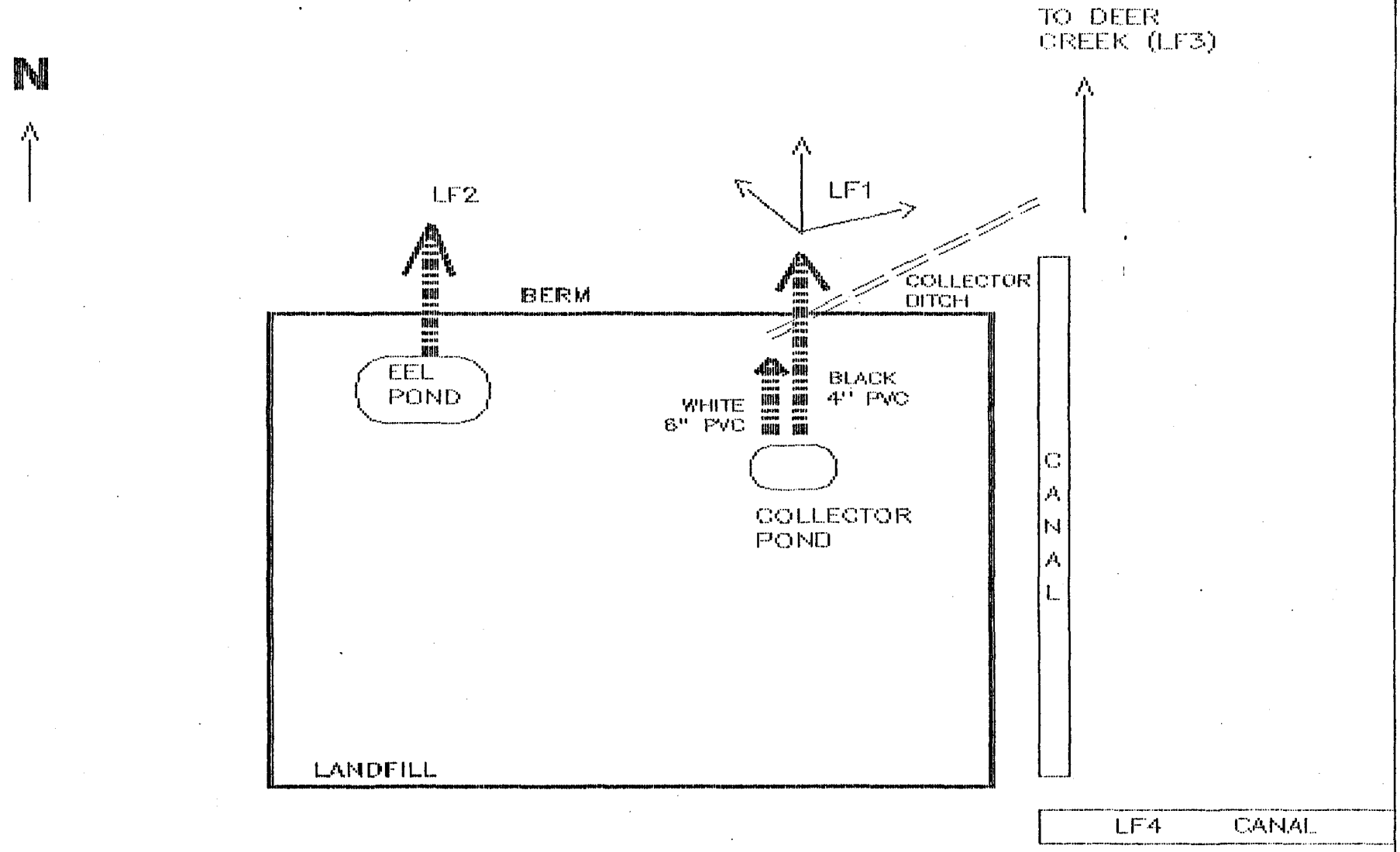

FIGURE 2. DARE COUNTY LANDFILL SCHEMATIC

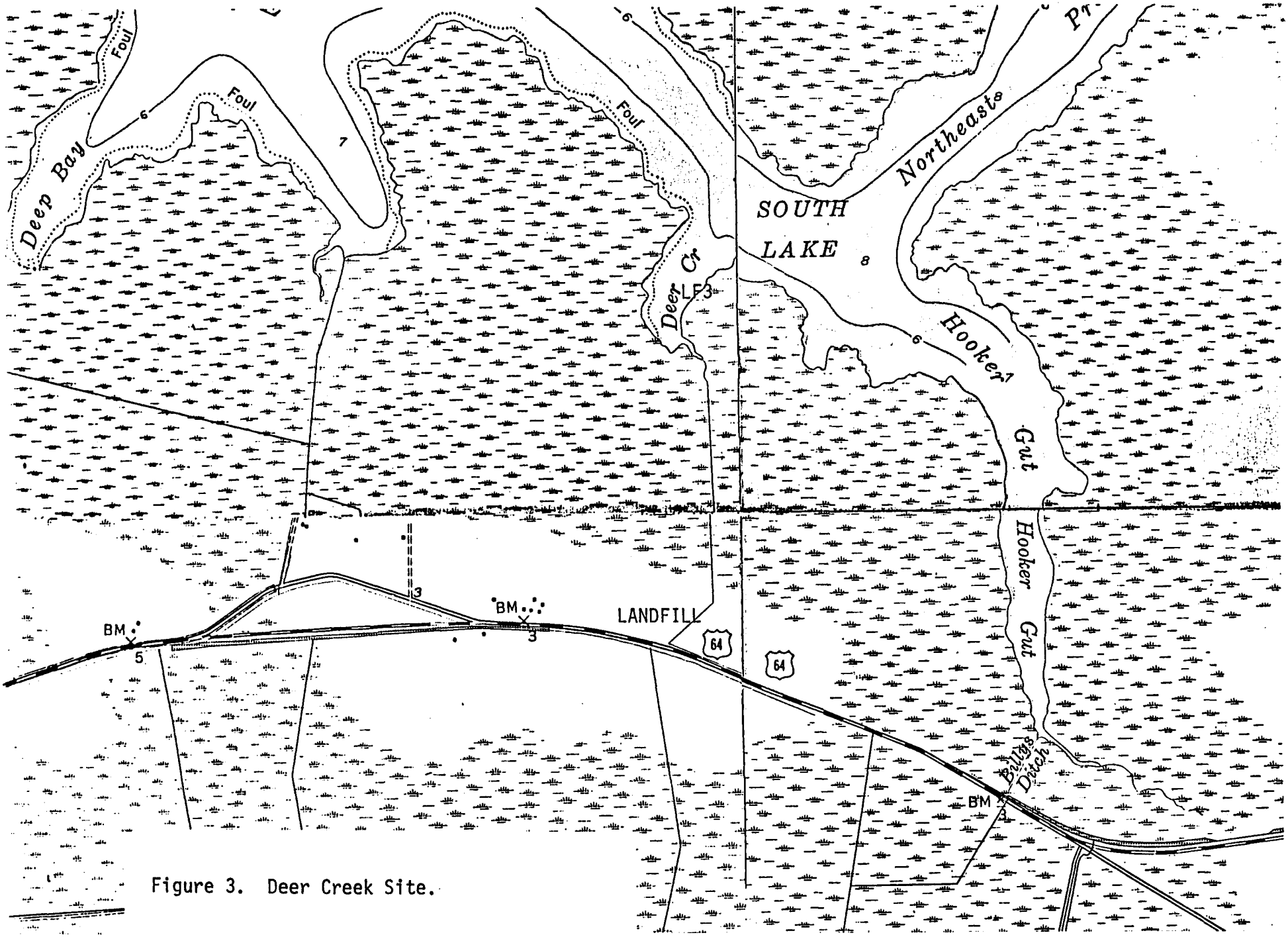

Figure 3. Deer Creek Site.